AMBIENT AIR QUALITY

IN

WINDSOR AND VICINITY

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Technical Support Section

Southwestern Region

ONTARIO MINISTRY OF THE ENVIRONMENT

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SUMMARY

The Ministry's air quality monitoring program conducted in the Windsor area showed that some areas experience unsatisfactory levels of specific air pollutants. However, for most of Windsor the levels of the measured air pollutants are satisfactory.

The 1986 levels of suspended particulates continued a trend of higher values which started in 1984. Excessive levels of suspended particulates were again measured near the casting plant of Ford Motor Company of Canada, Limited, the scrap metal operations of Zalev Brothers Limited and in west Windsor. Examinations of meteorological conditions and constituents in the suspended particulate matter sampled revealed the casting plant and the scrap metal operations to be significant sources of particulates that are adversely affecting ambient air quality. In west Windsor, the industrialized area of downriver Wayne County, Michigan, road traffic and the local salt company adversely affect ambient air quality.

In west Windsor there has been an appreciable increase in total reduced sulphur levels. Total reduced sulphur compounds tend to be malodorous. The elevated levels in west Windsor are associated with winds blowing from the direction of the coke ovens of the steel industry in Wayne County, Michigan.

Excursions were again detected above the desirable ambient air quality criterion established for ozone. Ozone is the most abundant photochemical oxidant in ambient air. The elevated levels are partly a result of long-range transport of oxidants and precursor chemicals into the Windsor area. Ontario has established a special program to study the oxidant situation and to develop an appropriate control strategy. The U.S. Environmental Protection Agency is requiring individual states to implement oxidant control strategies by the end of 1987.

SOMMAIRE

Le programme ministériel de surveillance de la qualité de l'air mené dans la région de Windsor a révélé que dans certains secteurs les concentrations de polluants atmosphériques particuliers sont inacceptables. Toutefois, les niveaux de polluants observés sont acceptables dans la plupart des secteurs de la ville.

En 1986, la tendance à la hausse constatée en 1984 au sujet des particules en suspension s'est poursuivie. Des concentrations excessives de particules en suspension ont été relevées une fois de plus à proximité de la fonderie de la société Ford Motor Company du Canada Limitée, de l'entreprise de récupération de ferraille Zalev Brothers Limited et dans l'ouest de Windsor. L'examen des conditions météorologiques et des composants des particules en suspension a révélé que la fonderie et l'entreprise de récupération sont des sources importantes de particules qui ont un effet délétère sur la qualité de l'air ambiant. Dans l'ouest de Windsor, la qualité de l'air ambiant subit l'effet défavorable de la zone industrielle de Wayne County (Michigan) en aval, de la circulation routière et de la compagnie salinière locale.

Dans l'ouest de Windsor, la concentration totale de soufre réduit accuse une forte augmentation. Les composés du soufre réduit engendrent généralement de mauvaises odeurs. Les concentrations élevées dans cette partie de la ville s'expliquent par la direction des vents qui soufflent depuis les fours à coke des industries sidérurgiques implantées dans le Wayne County (Michigan).

On a de nouveau constaté que les critères souhaitables de la qualité de l'air établis pour l'ozone ont été dépassés. L'ozone est le plus abondant des oxydants photochimiques présents dans l'air ambiant. Les concentrations élevées sont imputables en partie au transport à grande distance d'oxydants et de produits chimiques précurseurs. L'Ontario a établi un programme spécial pour étudier le problème des oxydants et mettre au point une stratégie de lutte appropriée. L'Environmental Protection Agency des États-Unis exige des États qu'ils appliquent d'ici la fin de 1987 des stratégies de lutte contre les oxydants.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors in the Windsor area to measure levels of a number of pollutants that may adversely affect health, vegetation and the enjoyment of property. Data on the levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore, the effectiveness of pollution abatement. As well, information is provided on the effects of specific sources of pollutants and for use in the formulation of strategies to control emission sources. In addition to the air monitoring conducted at fixed sites, mobile air monitoring units are sometimes used especially for intensified monitoring near specific emission sources. The air monitoring program is complemented by the Ministry's phytotoxicology surveys which determine effects of air pollutants on vegetation.

This annual report deals specifically with ambient air quality data gathered from fixed monitoring sites in the Windsor area. Detailed information on pollution abatement activities may be obtained from the Windsor District Office.

DESCRIPTION OF MONITORING NETWORK

The Ministry operates continuous and intermittent ambient air monitors at fixed sites throughout the Windsor area. Ideally, monitoring would be conducted at the same sites year after year in order to provide a historical trend for air quality. However, many stations have had to be relocated or terminated because of local interferences or changing land-use patterns. Nevertheless, the number of existing historical stations is deemed adequate to evaluate the long-term trend information.

The main monitoring station is located in the downtown area in order to evaluate air quality where emissions from motor vehicles and commercial establishments are most prevalent. There are a number of monitoring stations in west Windsor, which is close to a heavily industrialized portion of Wayne County, Michigan.

In the vicinity of Zalev Brothers Ltd. there are a several monitoring stations that were established to better define the impact of emissions from the Company's scrap metal operations on neighbourhood air quality. In west Windsor a new meteorological tower was placed in operation in February 1986.

The location of the Ministry's monitoring stations in the Windsor area are indicated on Figure 1 and are described in Table A1 of Appendix 1.

The pollutants monitored at the various stations are listed in Appendix 1, Table A2. Ontario's criteria for desirable ambient air quality with respect to these pollutants and the prime factors supporting these criteria appear in Appendix 1, Table A3.

MONITORING AND PROGRAM RESULTS

PARTICULATES

The iron and steel industry, scrap metal operations and foundries, power generating plants utilizing fossil fuels and road traffic are primary sources of particulates that may adversely affect air quality in Windsor. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

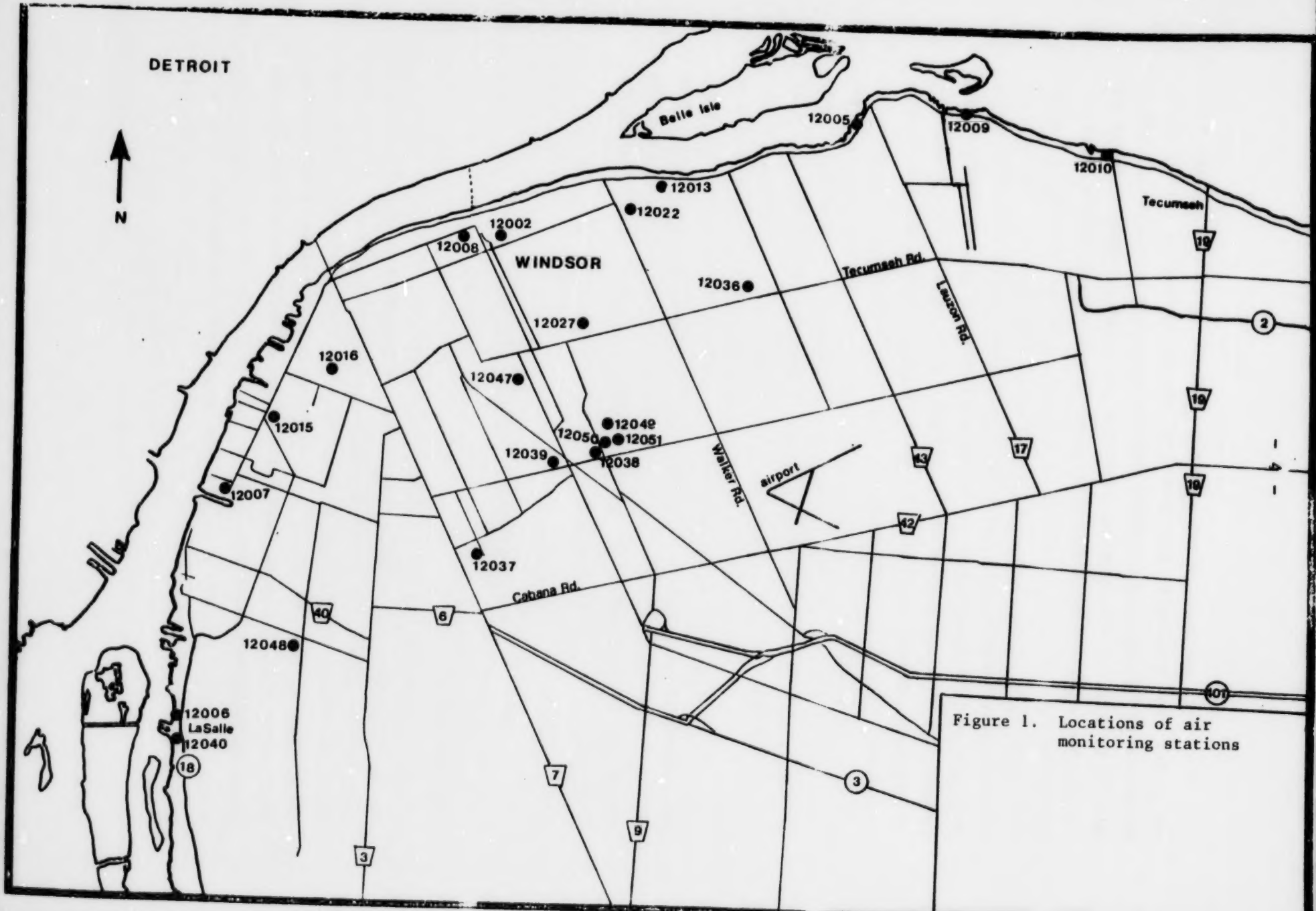


Figure 1. Locations of air monitoring stations

Measurements for particulates are reported as suspended particulates and soiling index. Levels of suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. The particulates trapped on the filters may also be analyzed for other parameters such as metals, sulphates and nitrates.

Soiling index is determined by measuring the difference in the amount of light transmitted through a filter before and after ambient air is drawn through the filter for one hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Light transmitted through the filter is measured by a photo-electric cell and the soiling index may be calculated immediately. This immediate availability of the soiling index in contrast with the time-consuming laboratory analysis required for total suspended particulate measurements has resulted in soiling index being used in the Air Pollution Index as an indicator of levels of suspended particulates.

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period. The other criterion is an annual geometric mean of 60 ug/m^3. The criterion for 24-hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1986 filters were exposed using Hi-Vol samplers at 18 sites in the Windsor area. At all sites, except stations 12008 and 12016, samples were collected on a frequency of every-sixth--day. At station 12008 sampling was conducted every day to provide information by which it could be determined if the every-sixth-day sampling schedule is representative of the whole year. At station 12016 an every-third-day schedule was utilized until May 8, 1986 when the every-sixth-day schedule resumed. A summary of total suspended particulate (TSP) data collected from 1972 through 1986 appears in Tables 1a and 1b. Figure 2 shows the annual geometric mean and the percentage of excursions above the 24-hour criterion for the various monitoring stations during 1986.

The data from the every-day sampling schedule at station 12008 indicated that suspended particulate levels were higher in 1986 than in 1985 and that levels for the every-sixth-day schedule in 1986 were greater than the levels for the every-day schedule. Therefore where increases in suspended particulate levels occurred at stations operated on the every-sixth-day sampling schedule, the increases may be attributed in-part to the 1986 every-sixth-day sampling schedule being representative of higher levels than the every-day schedule. Similarly, at stations where 1986 levels were lower, the improvement might have been even greater if the sampling schedule was representative of the whole year.

Figure 3 illustrates the average annual geometric mean for seven* monitoring stations in operation since 1972. Figure 4 illustrates the trend in frequencies of excursions above the 24-hour criterion for these same stations. The trend information indicates a reduction in particulate levels from 1972 through 1983 and an increasing trend since 1983.

Table 1A Summary of Data for Total Suspended Particulates, Annual Geometric Mean Concentrations (ug/m^3)

Station	Year														
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
12002	159	133	108	74	76	82	79	80	77	69	62	53	50	50	61
12005								63	55	45	45	36	38	41	48
12006												49	48	56	67
12007													(67)	73	72
12008	126	126	116	82	80	87	80	80	71	58	55	53	57	59	63
12008S											58	60	61	59	68
12009	79	82	61	52	58	54	52	57	58	46	46	36	36	43	45
12010	85	86	58	46	54	47	46	53	47	40	39	31	33	42	53
12013	151	145	113	89	98	113	100	98	75	65	68	65	66	77	85
12015	183	147	152	105	113	93	93	98	108	87	70	59	79	90	86
12016				88	88	95	84	85	83	67	63	50	54	56	68
12036						72	63	72	70	55	53	49	49	53	58
12037						67	68	62	60	49	39	42	47	46	55
12038														(79)	69
12039								79	71	71	53	49	50	54	62
12047														46	49
12049														57	56
12050														75	(77)
12051															(58)

( ) - Annual geometric mean and percentage of values above 24 hour criterion based on data not representative of total year.

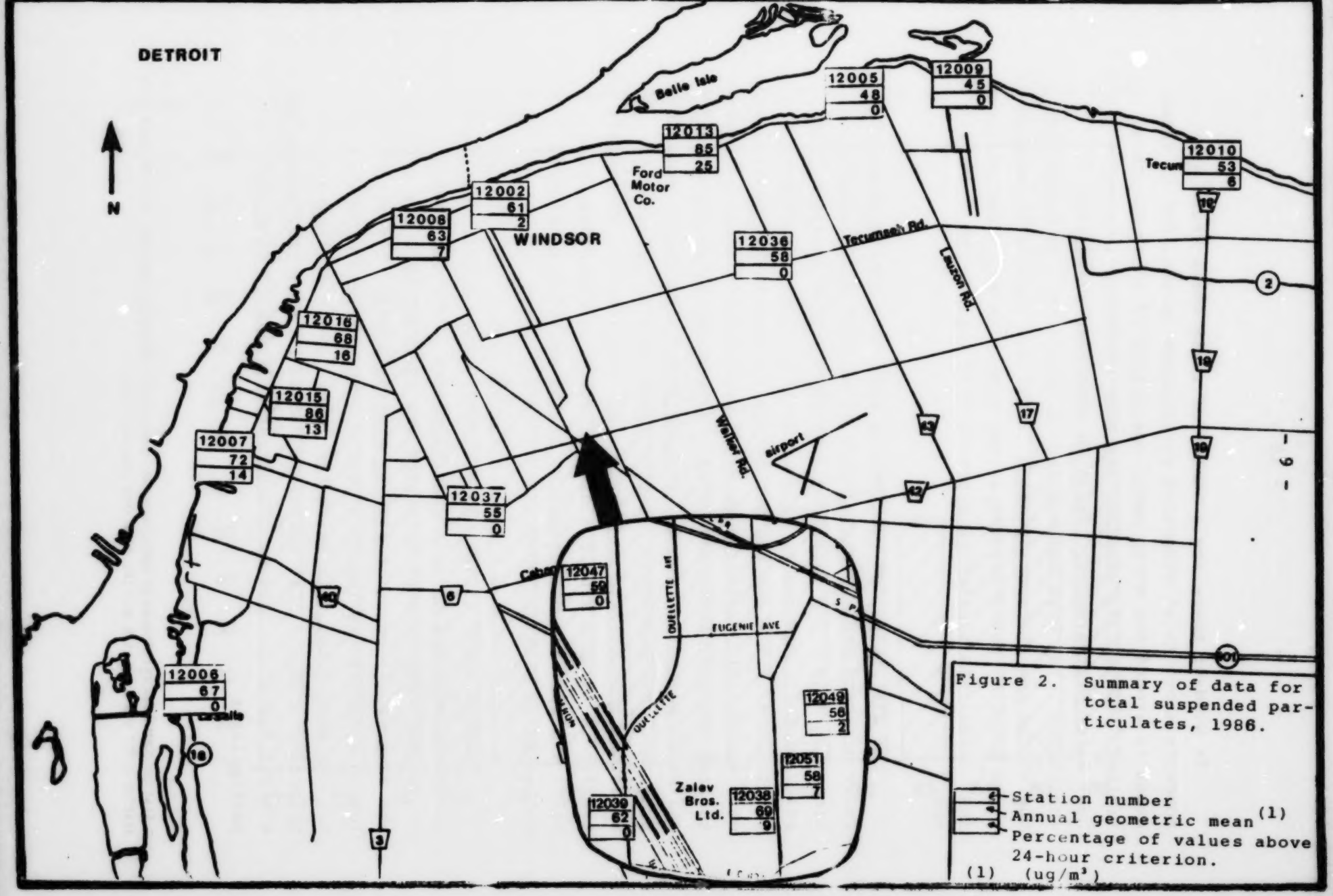
Data for station 12008S are every sixth day sampling results extracted from the daily sampling data for station 12008.

Table 1B Summary of Data for Total Suspended Particulates: Percentage of Values Above 24 Hour Criterion

Station	Year														
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
12002	70	58	43	14	15	21	18	16	19	9	11	4	0	2	2
12005							4	4	2	2	2	0	2	2	0
12006												6	0	2	0
12007													(7)	15	14
12008	57	55	47	17	19	24	16	17	12	6	4	2	5	4	7
12008S											4	4	6	9	12
12009	16	25	10	2	5	7	9	4	9	0	4	0	0	4	0
12010	23	27	17	2	10	6	7	0	0	0	0	0	0	2	6
12013	65	69	44	26	37	40	40	42	15	5	18	16	14	18	25
12015	80	66	84	33	42	25	27	33	46	16	8	3	22	24	13
12016				20	24	22	23	20	20	6	5	3	5	5	16
12036						11	9	15	13	2	2	0	2	2	0
12037						10	15	2	2	2	2	0	2	2	0
12038														(15)	9
12039								14	8	3	6	2	0	2	0
12047														2	0
12049														6	2
12050														25	(25)
12051															(7)

( ) - Annual geometric mean and percentage of values above 24 hour criterion based on data not representative of total year.

Data for station 12008S are every sixth day sampling results extracted from the daily sampling data for station 12008.


DETROIT
N
Belle Isle
12005
48
0
12009
45
0
12013
85
25
Ford
Motor
Co.
12010
53
6
Tecum
12002
61
2
12008
63
7
WINDSOR
12036
58
0
Tecumseh Rd.
Lauzon Rd.
12016
68
16
12015
86
13
12007
72
14
Walker Rd.
airport
12037
55
0
12047
59
0
Ouellette Ave
Eugenie Ave
12006
67
0
12049
58
2
12051
58
7
Zalev
Bros.
Ltd.
12038
69
9
12039
62
0
Figure 2. Summary of data for total suspended particulates, 1986.
Station number
Annual geometric mean (1)
Percentage of values above 24-hour criterion.
(1) (ug/m³)

In Windsor there are a number of areas where there are concerns about total suspended particulate levels. One of these areas is around the scrap metal operations of Zalev Brothers Limited. Since 1979 sampling has been conducted at station 12039 near Zalev Brothers Ltd. Early in 1985 four additional monitoring sites were established in this area. In March 1986 one of the new stations (station 12050) was terminated because of a new building being erected at the site. In May a new station (no. 12051) was started at a new site to replace the terminated one.

The 1986 suspended particulate data from the stations near Zalev Brothers Ltd. were evaluated along with wind speed and direction data. The data reveal an impact from emissions from Zalev Brothers Limited at all six sites. Total suspended particulate levels and the percentage of iron in the particulates were appreciably greater when winds were blowing from the company towards the air monitoring sites. At station 12039 the annual criterion was not exceeded. Besides being affected by emissions from Zalev Brothers Ltd., station 12039 is also affected by emissions from traffic on the E.C. Row expressway. The impact of traffic is evident from the higher levels of chlorides (road salt) and lead (leaded gasoline) in the particulate samples collected at station 12039.

Station 12038 is located at the Ivy Rose Motel. The annual geometric mean was 69 ug/m^3 and therefore above the annual criterion. The 24-hour criterion was exceeded by 9 per cent of the samples collected in 1986 at station 12038. Elevated iron levels indicate the impact of Zalev Brothers Ltd. emissions at the Ivy Rose Motel site while the lower levels of lead and chlorides indicate that emissions caused by road traffic are not a major factor in causing the elevated levels of suspended particulates.

* Station 12032 was terminated in April 1984 and for trend information the 1984 to 1986 data from station 12007 was used with earlier data from station 12032.

Figure 3. Trend in annual levels of suspended particulates based on averaged data from seven monitoring stations.

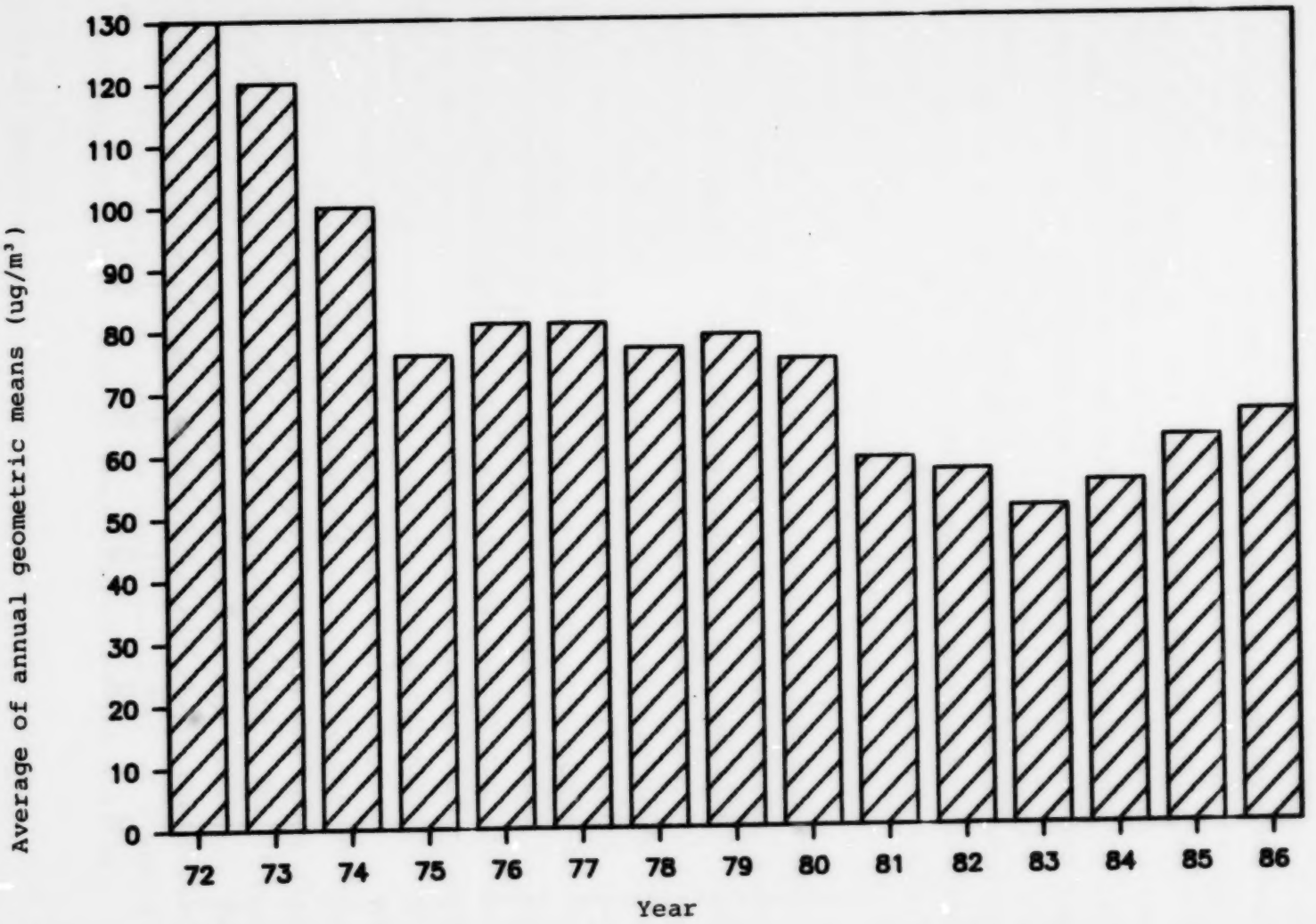
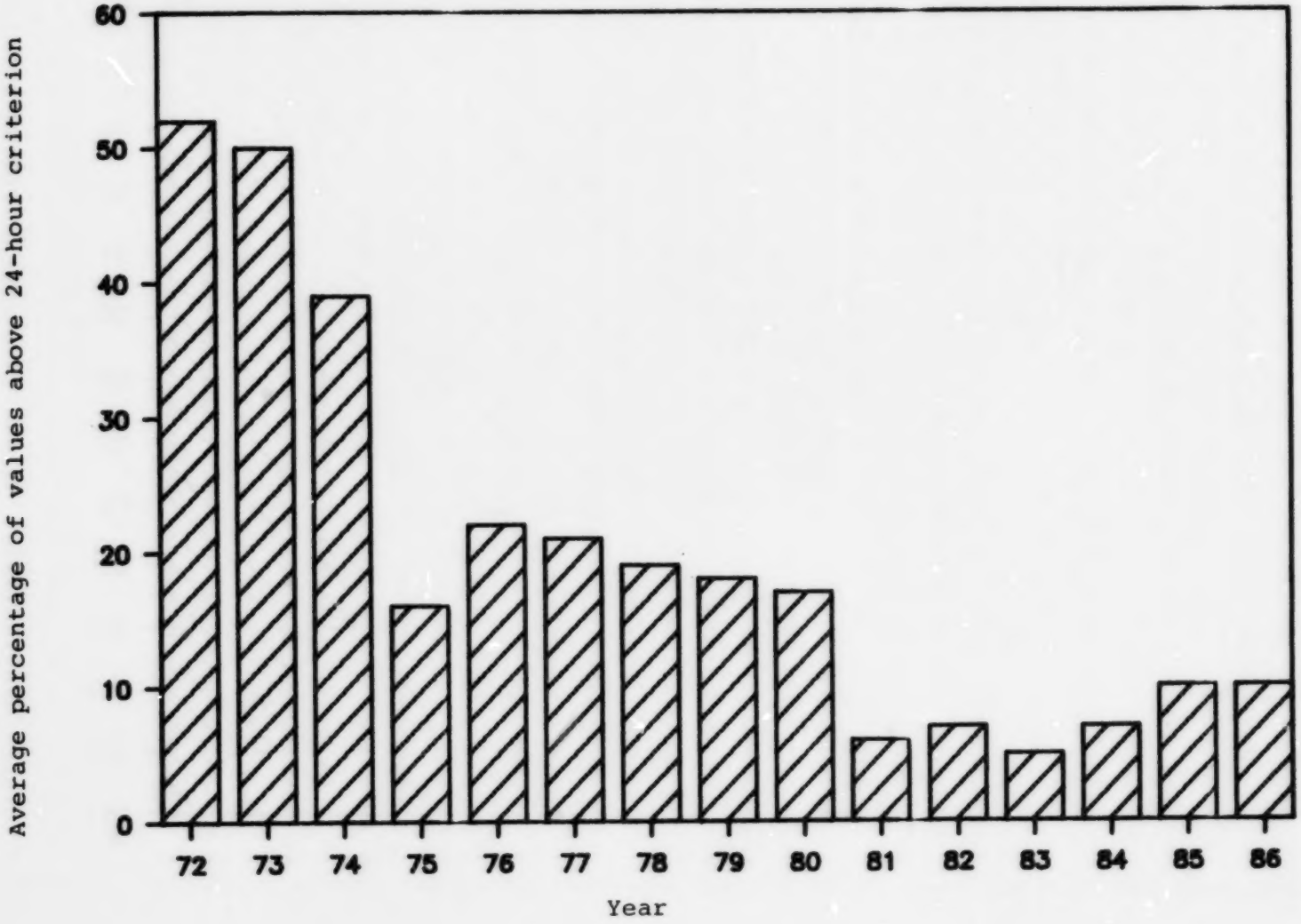


Figure 4. Trend in excursions above 24 hour criterion for total suspended particulates based on data from seven monitoring stations.



Station 12050 was operated for less than three months in 1986 and although elevated levels of suspended particulates were measured, the emissions from the constructions activity at the site makes it difficult to discern the impact of emissions from Zalev Brothers Ltd. Station 12051 was operated from May 1986 and although the annual criterion was not exceeded, the 24-hour criterion was exceeded by 7 per cent of the samples collected and iron levels were elevated compared to levels at monitoring sites in the same general area but farther from Zalev Brothers Ltd. At stations 12047 and 12049 the annual criterion was met and the 24-hour criterion was not exceeded at station 12047 and was exceeded by only 2 per cent of the samples collected at station 12049. Iron levels were generally lower at stations 12047 and 12049 than at stations closer to Zalev Brothers Ltd. The average iron levels for 1986 are illustrated in Figure 5.

In addition to the total suspended particulate samples collected in the vicinity of Zalev Brothers Ltd., soiling index samplers were deployed at stations 12038, 12039 and 12049. The soiling index samplers collect samples for a 1-hour duration compared to the 24-hour duration of the Hi-Vol sampler. The soiling index samplers also collect suspended particulates that are representative of a smaller size range of particulate matter than the Hi-Vol sampler. The soiling index samplers used in the vicinity of Zalev Brothers Ltd. are a new design and problems were encountered because the samplers are extremely sensitive to changes in ambient temperature. Data for the first part of 1986 are suspect but have been included in the report (Table 2). The annual criterion for soiling index is 0.5 coefficient of haze (COH) units per 1000 ft of air and this criterion was exceeded at stations 12038 and 12039 but not at station 12049. The 24-hour criterion is 1.0 COH per 1000 feet of air. This criterion was exceeded most frequently at station 12039 (9.2% of the values) and to a lesser degree at stations 12038 and 12049 (3.7 and 4.0 per cent respectively). However when evaluating the soiling

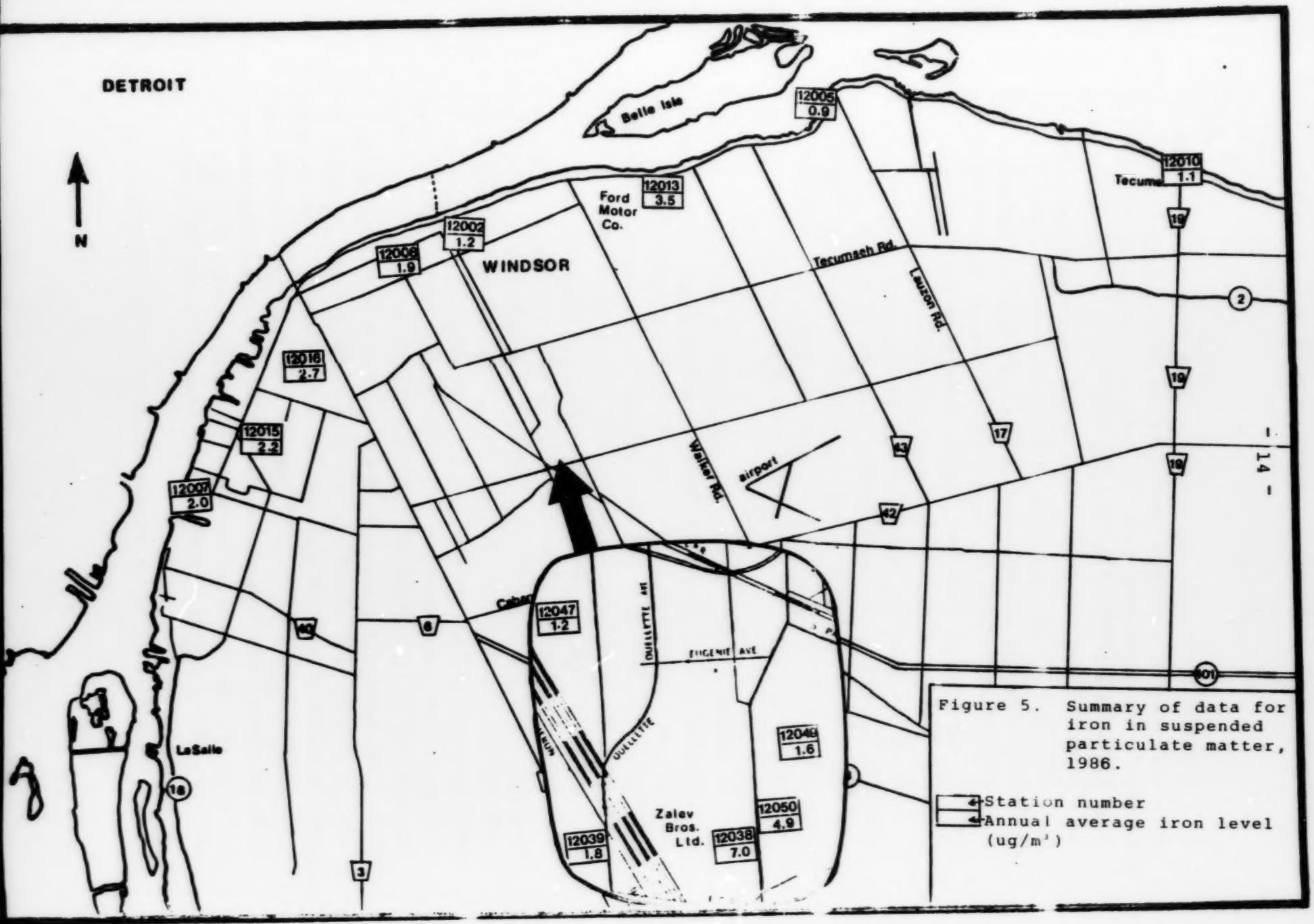


Figure 5. Summary of data for iron in suspended particulate matter, 1986.

Station number
Annual average iron level (ug/m³)

index data with wind direction data an impact from Zalev Brothers Ltd. is not obvious. This may be because the soiling index sampler collects smaller-sized particles and any impact from Zalev Brothers Ltd. is masked by the smaller-sized particles associated with the long-range transport of air pollutants.

The monitoring program indicated a localized impact from Zalev Brothers Limited, especially at the Ivy Rose Motel where total suspended particulate levels were elevated. Also, the 1986 levels of suspended particulates were appreciably lower than the levels for 1985 with fewer excursions of the 24-hour criterion being experienced in 1986.

Table 2 Summary of Soiling Index Data

Station Number	No. of 1 Hour Values	Annual Average Soiling Index (1)	No. of Values Greater Than 24 Hour Criterion	% of Values Greatern Than 24 Hour Criterion
12038	7206	0.52	11	3.7
12039	5711	0.57	21	9.2
12049	6736	0.45	11	4.0

(1) Soiling index is expressed as co-efficient of haze per 1000 feet of air. The annual criterion is 0.5 COH. The 24 hour criterion is 1.0 COH.

Another area of concern is in the vicinity of the casting plant of Ford Motor Company of Canada Limited. Station 12013 is the closest monitoring station to the casting plant. Levels of total suspended particulates were greater in 1986 compared to 1985. This is the second consecutive year in which total suspended particulate levels have increased appreciably at station 12013. The 1986 annual geometric mean of 85 ug/m^3 was the highest for this station since 1979 and well in excess of the 60 ug/m^3 annual criterion. The 24-hour criterion of 120 ug/m^3 was exceeded 25 per cent of the time, the greatest frequency of excursions since 1979.

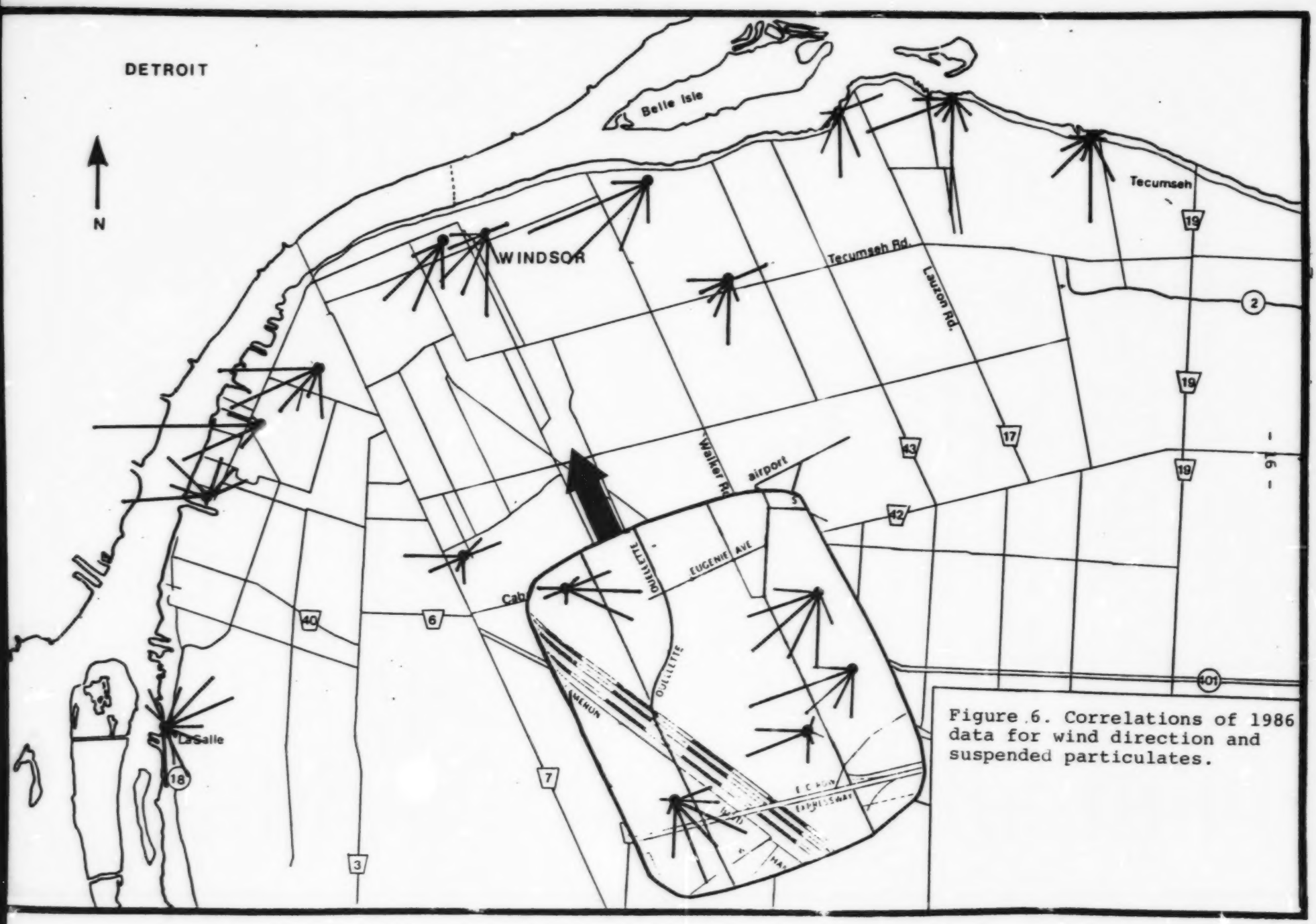


Figure 6. Correlations of 1986 data for wind direction and suspended particulates.

During 1986, total suspended particulate levels greater than 200 ug/m^3 were measured on 5 occasions at station 12013, once at station 12015 in west Windsor and not at any other of the 16 suspended particulate monitoring sites in Windsor. The 200 ug/m^3 is an arbitrarily selected level selected by the author and is not associated with an air quality criterion. However, the 200 ug/m^3 level effectively demonstrates that the highest levels of total suspended particulates are measured at station 12013 which is near the casting plant.

A review of the air quality data for December 22, 1986 illustrates the influence of the casting plant on the surrounding air quality. At station 12013 the total suspended particulate level was measured at 267 ug/m^3, the iron level was 13 ug/m^3 and winds were blowing from the general direction of the casting plant towards station 12013.

Figure 5, which illustrates the average iron levels for the Windsor monitoring stations in 1986, shows that elevated levels of iron are experienced at station 12013 compared to most other monitoring stations. A correlation of total suspended particulate results with meteorological data indicates that higher levels of suspended particulates were measured at station 12013 when winds were blowing from the casting plant towards the monitoring station. The correlations for the various monitoring stations are depicted in Figure 6, with the longer lines indicating higher total suspended particulate levels being experienced with winds from those particular wind directions.

There is concern about the level of suspended particulate matter in west Windsor. In recent years, the highest levels of total suspended particulate matter have been measured at station 12015. In 1986 the level of total suspended particulates were

lower at station 12015 than in 1985. The 1986 annual geometric mean of 86 ug/m^3 is lower than the 1985 value of 90 ug/m^3 but is appreciably higher than the 60 ug/m^3 annual criterion. The frequency of excursions above the 24-hour criterion was 13 per cent in 1986 compared to 24 per cent in 1985.

Sources affecting the suspended particulate levels at station 12015 are the industries in the downriver area of Wayne County, traffic in west Windsor and the local salt company. The chloride content of the suspended particulate matter collected at station 12015 would reflect the impact of emissions from traffic because of road salt and emissions from the local salt company. The chloride levels at station 12015 are twice as high as the levels measured at station 12039 which is near the E.C. Row expressway and affected by road salt. This would indicate that in addition to the impact from traffic, the elevated chloride levels at station 12015 are a result of emissions from the salt company. This is further exemplified by some of the higher chloride measurements at station 12015 corresponding with summer months when road salt is not used. The highest chloride measurement was found in a sample collected on September 5, 1986. Although the chloride levels are elevated at station 12015, the 1986 levels were 49 per cent lower than the 1985 levels.

At station 12015 iron and manganese levels in suspended particulate matter were lower in 1986 compared to 1985. Iron and manganese are used to detect the impact of emissions form the iron and steel industry and therefore, part of the decrease in TSP levels at station 12015 is attributed to a reduction in the impact of emissions from that industry.

The correlations between total suspended particulate matter and meteorological data referred to earlier and illustrated in Figure 6, indicate an impact in west Windsor when winds are blowing from the industrialized downriver area of Wayne County.

In addition to analyzing samples from some monitoring stations for iron, manganese, lead and chloride, suspended particulate samples were also analyzed for cadmium, chromium, nickel, vanadium, nitrates and sulphates.

A summary of these data collected from 1981 through 1986 is presented in Appendix 2, Table A4. Data for sulphates and nitrates are erroneously high based on the findings of several studies of the sampling method utilized by the Ministry. In the near future the type of filter used by the Ministry may be changed to provide more accurate nitrate and sulphate values.

Criterion for desirable ambient air quality exist for cadmium, lead, nickel and vanadium (listed in Table A3). Concentrations of the various metals have been traditionally low with no values above the criterion.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. The primary emitters of sulphur oxides are power generating plants and industries utilizing fossil fuels to meet requirements for large amounts of energy.

During 1986 sulphur oxides were measured in Windsor as gaseous sulphur dioxide and as sulphate in suspended particulate matter. Data for sulphate in suspended particulates are presented in Table A4 supporting the section on Suspended Particulates.

The criteria for desirable ambient air quality with respect to gaseous sulphur dioxide are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for 1 hour, 0.10 ppm averaged for 24 hours (midnight to midnight) and 0.02 ppm as an annual

average. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion serves to protect human health.

These criteria were not exceeded during 1986 at any of the six fixed locations in Windsor where the Ministry monitors sulphur dioxide. The monitoring locations are shown in Figure 1 as stations 12007, 12008, 12013, 12016, 2047 and 12048. A summary of the 1986 data is presented in Table 3.

Table 3 Summary of 1986 Sulphur Dioxide Data

Station Number	Annual Average (ppm)	Highest 1 Hr. Value (ppm)	Highest 24 Hr. Value (ppm)	Percentage of Values Greater Than 1 Hr Criterion	Percentage of Values Greater Than 24 Hr. Criterion
12007	0.01	0.18	0.04	0	0
12008	0.01	0.20	0.04	0	0
12013	0.01	0.13	0.03	0	0
12016	0.01	0.14	0.04	0	0
12047	0.01	0.10	0.03	0	0
12048	0.01	0.18	0.03	0	0

In recent years levels of sulphur dioxide have been satisfactory and appreciably lower than the levels experienced in the early 1970's. The improvement is illustrated in Figures 7 and 8 which respectively show the frequencies of excursions above the 1-hour and the 24-hour criteria for sulphur dioxide as measured at station 12008 in downtown Windsor.

Figure 7. Trend in excursions above 1-hour criterion for sulphur dioxide at station 12008

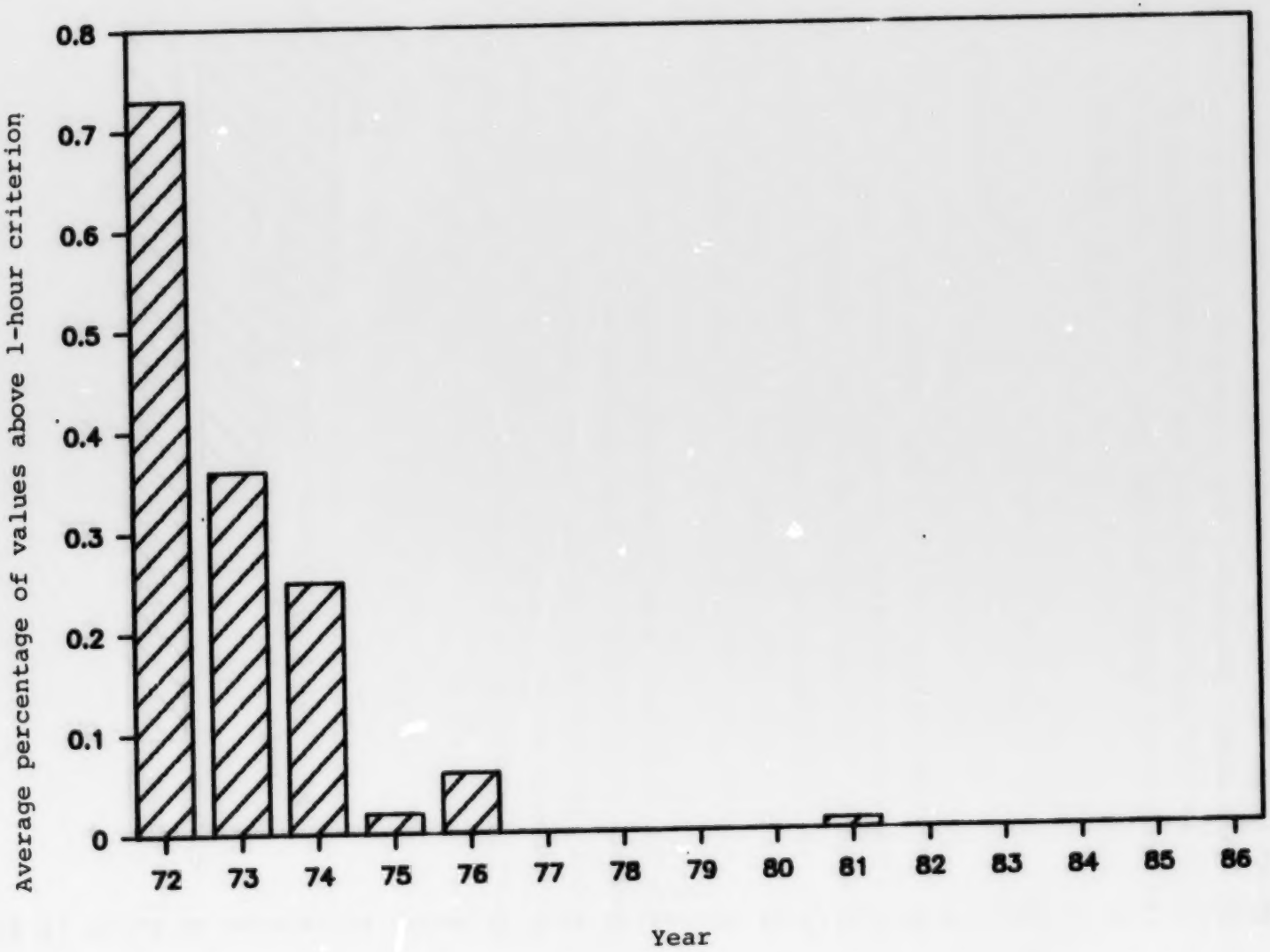
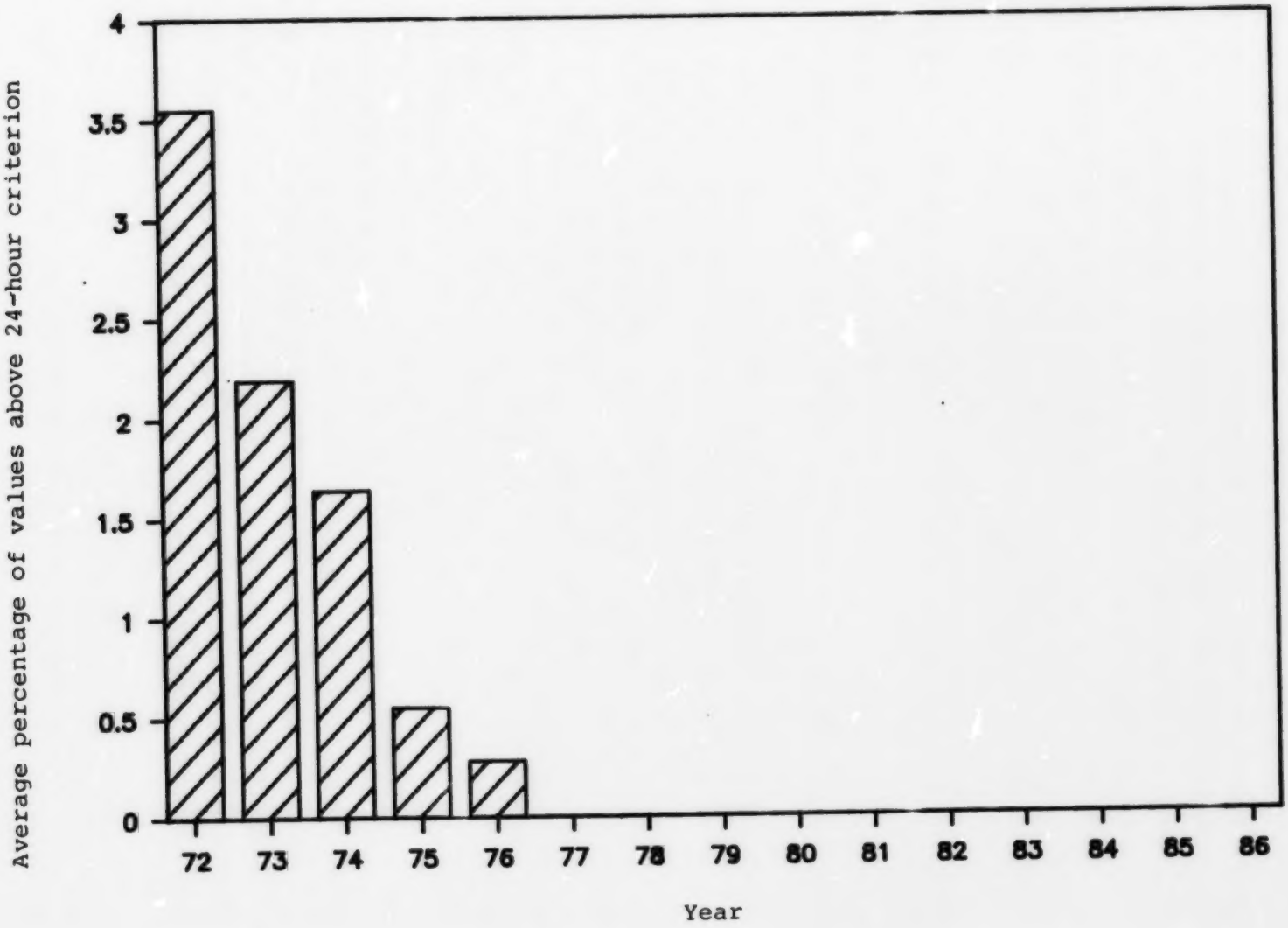


Figure 8. Trend in excursions above 24-hour criterion for sulphur dioxide at station 12008



Pollution roses showing the average concentration of sulphur dioxide assoicated with winds from different directions appear in Figure 9. These roses indicated higher average concentrations when winds are blowing from Michigan towards the monitoring stations in Windsor. However, the repeated conformity to criteria for desirable ambient air quality indicate that Michigan sources of sulphur dioxide are not adversely affecting air quality in Windsor.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of deteriorating air quality conditions that are numerically reported as the API.

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are used to compute 24-hour running averages which are inserted into the following equation:

$$API = 0.78\ (18.26\ COH + 156.7\ SO_2)^{1.06}$$

where: COH is the 24-hour average for soiling index expressed in co-efficient of haze units.

SO_2 is the 24-hour average concentration of sulphur dioxide expressed in parts per million.

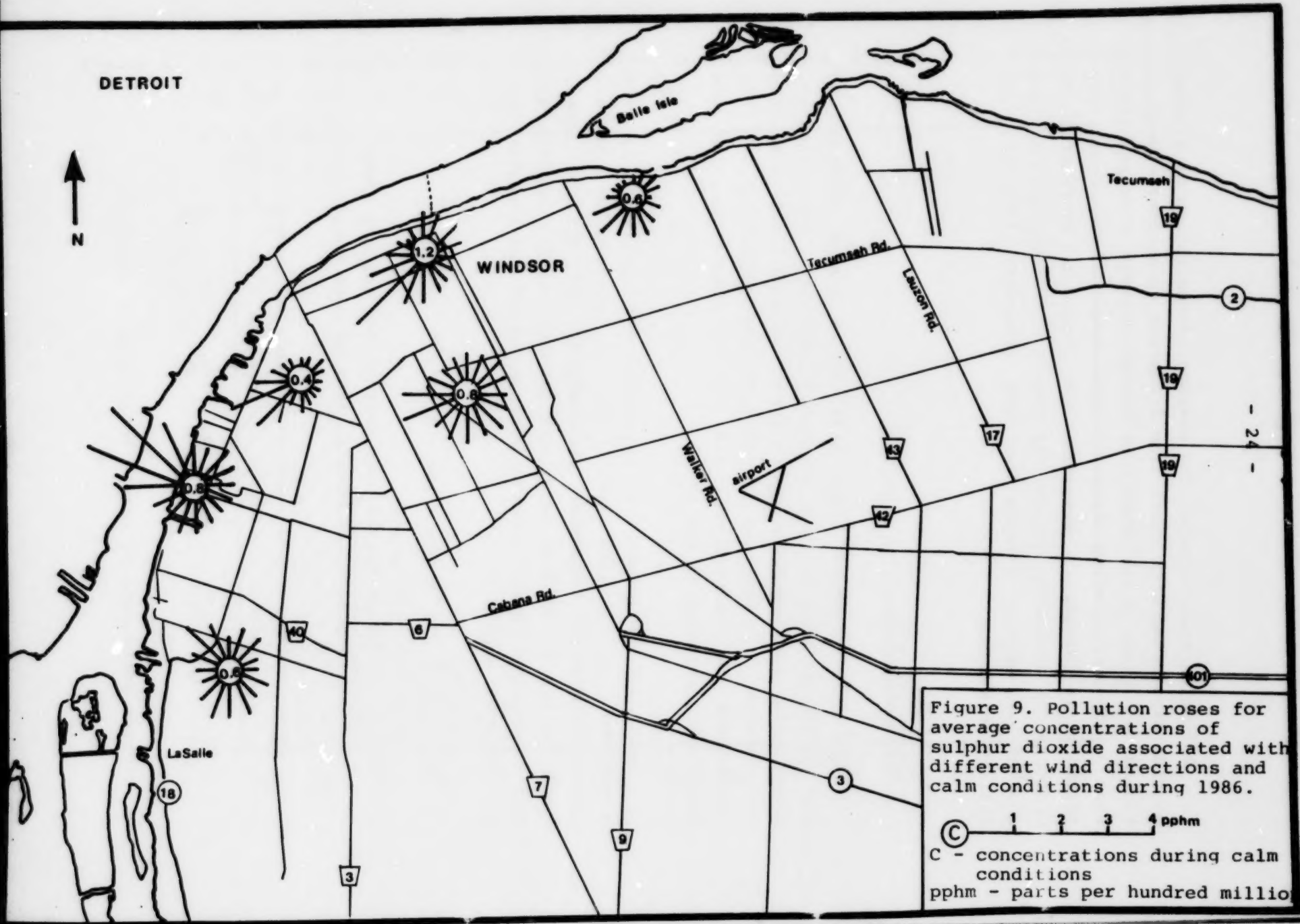


Figure 9. Pollution roses for average concentrations of sulphur dioxide associated with different wind directions and calm conditions during 1986.

C 1 2 3 4 pphm

C - concentrations during calm conditions

pphm - parts per hundred millio

API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emitters are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other pollution generating activities not essential to public health and safety can be ordered to cease operation.

Levels of soiling index and sulphur dioxide utilized for the computation of the API are obtained at station 12008 in downtown Windsor, and at station 12016 in west Windsor. During 1986 all API values were below the Advisory Level of 32.

TOTAL REDUCED SULPHUR

Gaseous total reduced sulphur compounds often exhibit malodours at very low concentrations. Hydrogen sulphide is a reduced sulphur compound commonly referred to as rotten egg gas. Mercaptans are also reduced sulphur compounds that exhibit characteristics similar to hydrogen sulphide, including being malodorous at extremely low concentrations.

There are many sources of reduced sulphur compounds including natural decomposition of organic material. In west Windsor there are occasional malodours which may be caused by reduced sulphur compounds. Probable sources of these odours are the coking operations of the steel industry in Wayne County, Michigan and sewage composting in West Windsor. There has also been suspicion that some of the malodours experienced in the vicinity of the casting plant of Ford Motor Company of Canada, Limited may be caused by reduced sulphur compounds.

The Ministry of the Environment has a desirable ambient air quality criterion for mercaptans of 10 parts per billion (ppb) during a 1-hour period. There is also a criterion for hydrogen sulphide which is 20 ppb during a 1-hour period. These criteria were established on the basis of odour. Unfortunately the instrument used by the Ministry to measure total reduced sulphur compounds does not differentiate between hydrogen sulphide and mercaptans. The instrument reports the combined levels of hydrogen sulphide and mercaptans as total reduced sulphur, expressed as hydrogen sulphide. In consideration of the combined levels measured by the instrument, the levels are compared with the less restrictive criterion for hydrogen sulphide.

During 1986 monitoring for total reduced sulphur was conducted at station 12007 in west Windsor and station 12013 near the casting plant of Ford Motor Company of Canada, Limited. At station 12007 a fluorescence-type monitor was used in 1986 and 1985. However, the reduced sulphur converter for 1985 was operated at 300 degrees celsius while for 1986 a converter temperature of 960 degrees celsius was used. The higher temperature will convert some reduced sulphur compounds not converted at lower temperatures and therefore higher total reduced sulphur compounds would be measured. However, the temperature change had a minimal impact on the total reduced sulphur compound concentration based on an evaluation with two different monitors operating simultaneously at station 12007. At station 12013 a coulombmetric-type total reduced sulphur monitor was used until June 1986 when it was replaced with a fluorescence-type monitor.

No excursions were measured at station 12013. At station 12007 there were 176 measured excursions above the 1-hour criterion. This represents 2.04 per cent of the measurements in 1986 being greater than the 1-hour criterion compared to 0.79 per cent in 1985. A summary of data for total reduced sulphur compounds is presented in Appendix 3, Table A5.

The elevated levels of total reduced sulphur compounds at station 12007 are associated with winds blowing from the heavily industrialized area of Zug Island in Wayne County, Michigan. Figure 10 contains pollution roses that show the average concentration of total reduced sulphur compounds associated with various wind directions as measured at the 46-metre level at station 12007. The rose for station 12007 indicates much higher levels of total reduced sulphur compounds occur when the winds are blowing from Zug Island towards the monitoring station. Ministry staff servicing the equipment at station 12007 frequently detect rotten-egg type odours when the winds are blowing from Zug Island.

No impact has been detected by the monitor when winds are bowing from the West Windsor composting operation. The rose for station 12013 shows that average concentrations are low for all wind directions although they are higher when the winds are blowing from the west-southwest and southwest. These winds would blow emissions from the casting plant of Ford Motor Company and emissions from the Zug Island area towards the monitoring station. Consequently the increased levels cannot be attributed solely to either the casting plant or Zug Island but since the levels are low and the desirable ambient air criterion is met, this does not create any difficulty.

Three years of monitoring total reduced sulphur compounds near the casting plant of Ford Motor Company has not revealed any levels above the desirable ambient air quality criterion. Consequently the complaints concerning malodorous in the area must be caused by chemicals other than total reduced sulphur compounds. Further investigations are required to identify the offending compounds. The total reduced sulphur monitoring at station 12013 is to be suspended at the end of 1987.

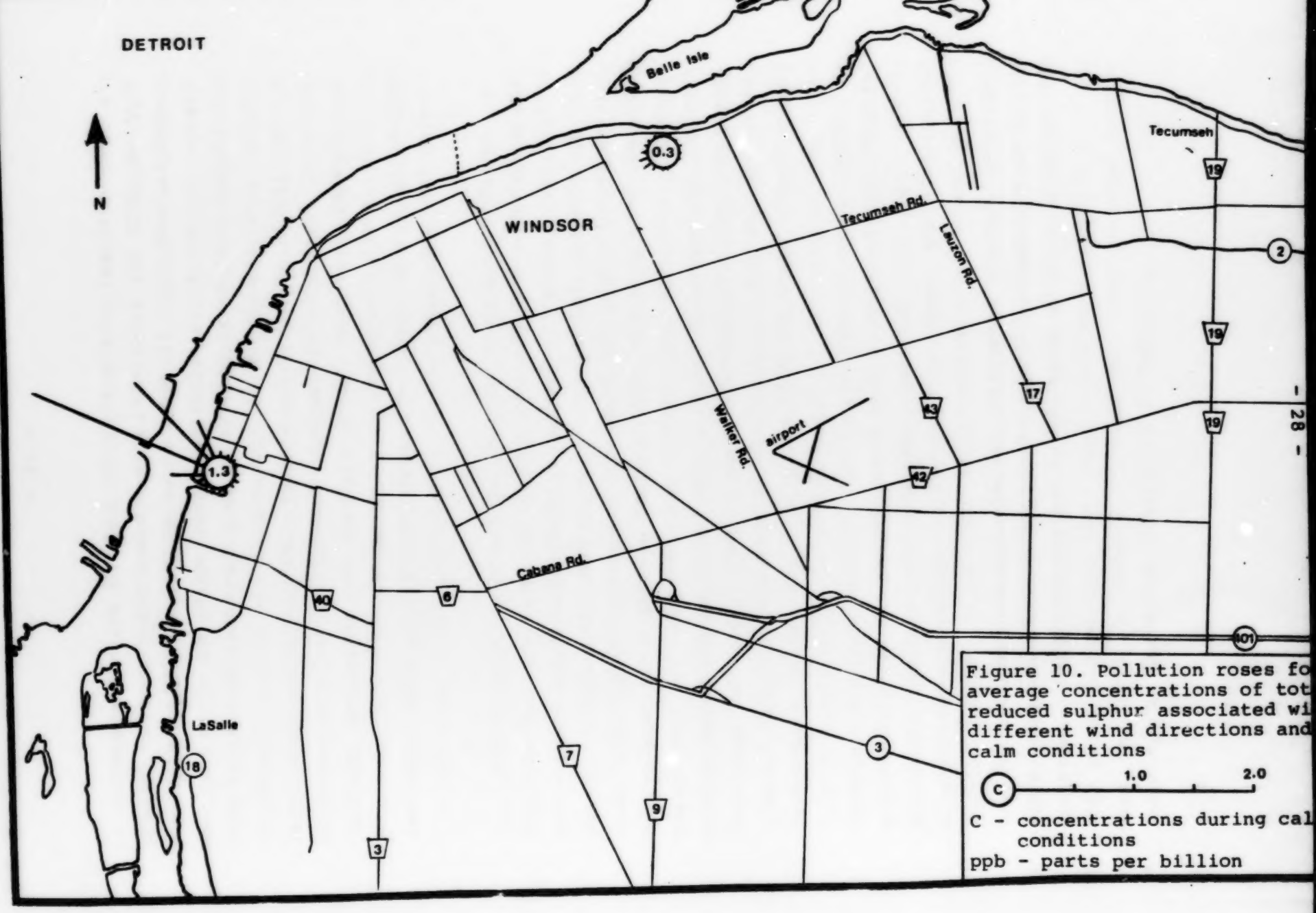


Figure 10. Pollution roses fo
average concentrations of tot
reduced sulphur associated wi
different wind directions and
calm conditions

C 1.0 2.0

C - concentrations during cal
conditions
ppb - parts per billion

CARBON MONOXIDE

Combustion processes account for man's major emissions of carbon monoxide. Emissions from motor vehicles are especially significant because they are near ground level and are concentrated in urban areas where the public may be exposed for long periods. Major industries and power generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in ambient air.

The criteria for carbon monoxide are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8 hours. These criteria were established for the protection of human health and have not been exceeded in the past 10 years, based on monitoring at station 12008. Since this station is located in the downtown area of Windsor where the highest levels of carbon monoxide are anticipated, there is a high probability that levels are acceptable throughout the Windsor area.

A summary of data for carbon monoxide, obtained since 1976, is presented in Appendix 3, Table A5.

OXIDES OF NITROGEN

Like many other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria for nitrogen dioxide, which are based on the protection of human health and offensive odours, are 0.20 ppm averaged for 1 hour and 0.10 ppm averaged for 24 hours (midnight to midnight).

During 1986, the criteria were not exceeded. The 24-hour criterion has not been exceeded at station 12008, located in downtown Windsor, since the chemiluminescence-type monitor was installed in 1974. During the same time period there has been only one excursion above the 1-hour criterion. Since emissions from motor vehicles are concentrated in the downtown area, levels of oxides of nitrogen would probably be higher at station 12008 than in other areas of Windsor. A summary of the data for oxides of nitrogen is presented in Table A5, Appendix 3.

Although levels of nitrogen dioxide have been very favourable when compared to the criteria, there is concern about oxides of nitrogen because of acidic precipitation and their role in the formation of unsatisfactory levels of photochemical oxidants. Consequently, more stringent controls for oxides of nitrogen are under consideration. New emission standards for 1988 model cars is one example of more stringent controls soon to be implemented.

HYDROCARBONS

The principal man-made sources of hydrocarbons are emissions from landfill sites and motor vehicles. Other significant man-made sources are incomplete combustion of fuels by industries and power generating plants and evaporation losses during manufacture, use, storage and transportation of materials containing volatile hydrocarbons. In the Windsor area, hydrocarbon emissions from distilleries and distillery warehouses account for a large proportion of emissions from stationary sources. Also emissions from motor vehicle painting are significant in the Windsor area. Natural phenomena produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Although there are no criteria for total hydrocarbons, monitoring for them provides information on trends in levels of hydrocarbons. Increasing levels of hydrocarbons could be significant should they be attributable to detrimental compounds. Furthermore, the non-methane or "reactive" hydrocarbons may partake in photochemical reactions which produce excessive levels of oxidants.

Total hydrocarbons, methane and non-methane hydrocarbons are monitored continuously at station 12008 in downtown Windsor using flame ionization detection. Continuous monitoring for other specific hydrocarbons is not done. However, when problems are suspected special monitoring surveys are conducted for specific hydrocarbons. These surveys are often very complicated and difficult and often must be repeated several times to properly identify and quantify specific hydrocarbons. Levels of total hydrocarbons and reactive hydrocarbons at station 12008 have been similar in recent years with no trend of changing levels apparent. A summary of annual average concentrations appears in Table A5, Appendix 3.

OXIDANTS

A major portion of the oxidants in ambient air are a result of photochemical reactions and inter-reactions involving oxides of nitrogen and reactive hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine. Consequently, higher levels of oxidants are experienced in the spring and summer months.

Ozone normally accounts for 80 to 90 percent of the photochemical oxidants in ambient air. The monitoring technology for ozone is more accurate and efficient than that for total oxidants. For these reasons, most regulatory agencies, including this Ministry, monitor for ozone rather than total oxidants.

Ozone is also present in the stratosphere where it plays the critical role of absorbing ultraviolet radiation that in excessive amounts may be biologically harmful. Occasionally ozone from the stratosphere may be transported downwards to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) can account for a very significant portion of local levels of ozone. Incidents of long-range transport from distances greater than 200 kilometres have been reported in the literature. Consequently, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

The Environmental Protection Agency (EPA) in the United States has established a primary standard for ozone of 0.12 ppm averaged for 1 hour. Individual states are required to bring ozone levels into compliance with the standard by the end of 1987.

The Ontario criterion for desirable ambient air quality is 0.08 ppm averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects detrimental to health that are associated with oxidants are eye irritation and a decrease in performance during physical activities. Oxidant damage to crops in Ontario is estimated at

millions of dollars annually. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop a suitable control strategy. More stringent standards are proposed for motor vehicles in Canada which should significantly reduce oxidant precursor emissions.

Ozone is monitored by a chemiluminescence-type instrument at station 12008, in downtown Windsor. During 1986 there were 39 hourly values reported in excess of the 1-hour criterion, all of which occurred during the months of April through August. With photochemical formation of ozone being dependent on meteorological conditions, there may be large fluctuations from year to year in the frequency of excursions above the criterion. A summary of ozone data, presented in Appendix 3, Table A5, shows that the frequency of excursions above the criterion was lower in 1986 than in any previous year since monitoring began in 1974.

A pollution rose for 1986 data is presented in Figure 11 to show the frequency of the total number of excursions above the criterion associated with different wind directions. The greatest frequency of excursions is associated with southerly winds. These winds are apt to be associated with the backs of high pressure systems or the area south of low pressure fronts which have weather favourable for photochemical reactions (clear sunny skies and warm temperatures) and which promote long-range transport of oxidants and their precursor chemicals.

FLUORIDES

Sources of fluorides in the Windsor area are the steel industry located in the downriver area of Wayne County, Michigan, power generating plants where coal burned contains trace amounts of fluorides, fluorspar unloading operations at docks in west Windsor and subsequent trucking of fluorspar to a location south of Windsor.

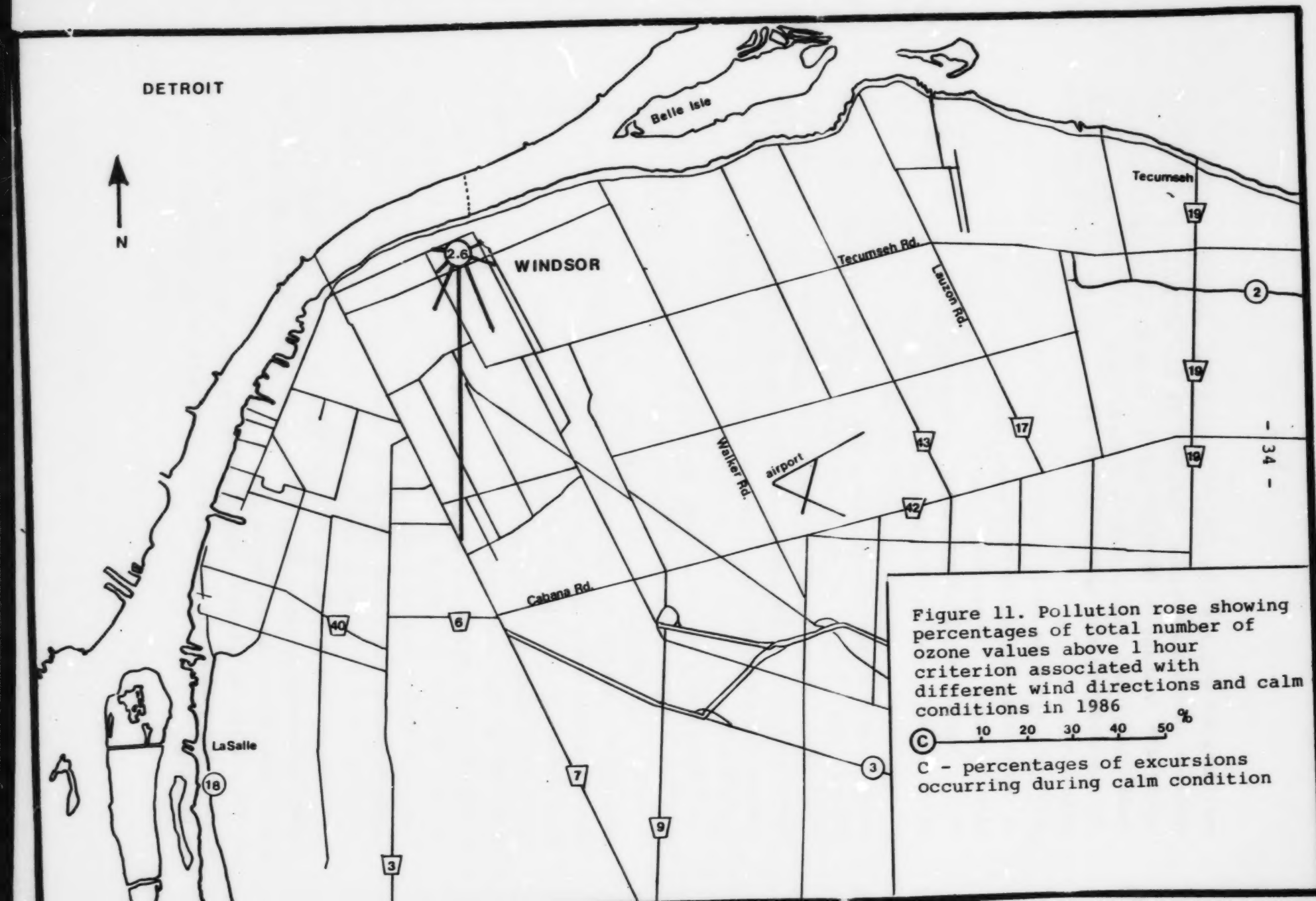


Figure 11. Pollution rose showing percentages of total number of ozone values above 1 hour criterion associated with different wind directions and calm conditions in 1986

C 10 20 30 40 50 %

C - percentages of excursions occurring during calm condition

Fluoridation rate is a measurement designed to indicate the relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and then analyzed for fluoride content. This monitoring technique measures primarily gaseous fluoride but some fluoride in particulate form may be collected on the filter.

The criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. Consequently, a criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ug F/100 cm^2/30 days) has been established for the growing season from April 15 to October 15 while a criterion of 80 ug F/100 cm^2/30 days applies for the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is measured on a monthly basis, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days). In recent years, investigations of vegetation have not revealed any appreciable damage to vegetation in Windsor attributable to fluorides.

During 1986 there were seven sites where fluoridation rates were monitored, 4 in west Windsor and 3 in the downtown area. The growing season criterion was exceeded once at station 12007 and once at station 12016. Both stations are located in west Windsor. The non-growing season criterion was not exceeded in 1986. Figure 12 shows that again in 1986 fluoridation rates were higher in west Windsor than in LaSalle or the downtown area. The 1986 fluoridation rates appear in Table 4.

Fluoridation rate is not considered a sensitive indicator of temporal trends of fluoride levels. However, based on data from six monitoring stations in operation since 1972 [1], the annual average of fluoridation rate and the frequencies of excursions

above the criteria for desirable ambient air quality have been lower in recent years, although average values for 1986 were slightly higher than the 1983 to 1985 levels. Figures 13 and 14 show the trend towards lower levels of fluoridation rates.

(1) Data for station 12007 has been used in substitution for data for station 12032 which was terminated in 1984.

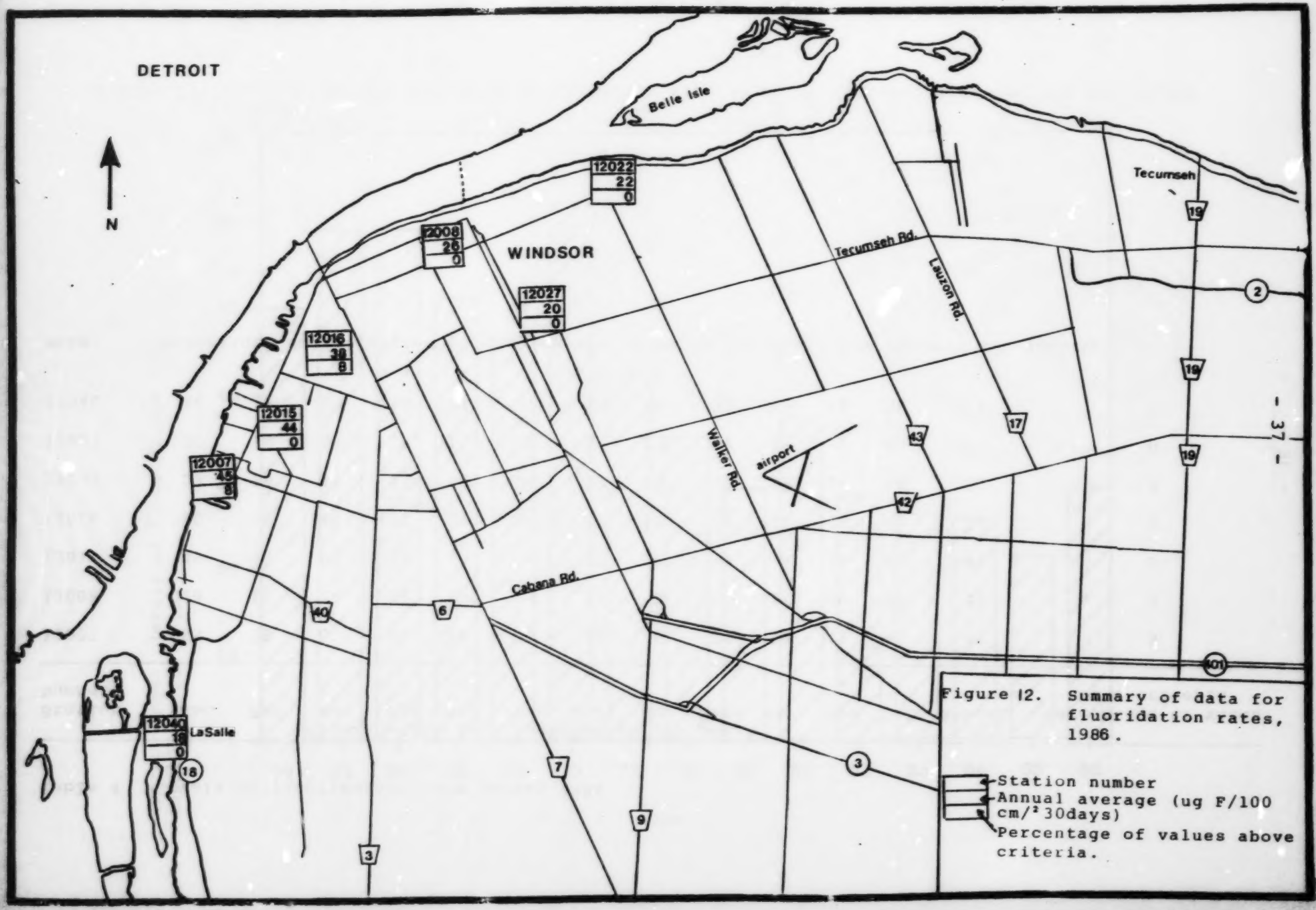

DETROIT
Belle Isle
N
WINDSOR
Tecumseh
Tecumseh Rd.
Lauzon Rd.
Walker Rd.
airport
Cabana Rd.
LaSalle
12022
22
0
12008
26
0
12027
20
0
12016
38
8
12015
44
0
12007
45
8
12040
18
0
Figure 12. Summary of data for fluoridation rates, 1986.
Station number
Annual average (ug F/100 cm/² 30days)
Percentage of values above criteria.

Table 4 Levels of fluoridation rate during 1986

Station Number	Fluoridation rate (ugF/100 cm^2/30 days) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average	Percentage of vaues above criteria
12007	65	39	61	46	22	19	20	26	<u>87</u>	38	49	65	45	8
12008	29	15	24	16	19	29	18	8	--	35	36	52	26	0
12015	49	35	62	38	33	39	37	27	--	--	49	68	44	0
12016	40	32	60	28	27	30	27	15	<u>51</u>	33	46	71	38	8
12022	27	19	17	15	18	20	27	15	20	15	24	46	22	0
12027	20	14	17	15	15	20	17	27	14	15	21	41	20	0
12040	36	18	18	13	14	10	15	10	18	12	18	38	18	0

Note: Underlined values exceed growing season criteria for desirable ambient air quality.

Figure 13. Trend in annual levels of fluoridation rate based on averaged data for six monitoring stations

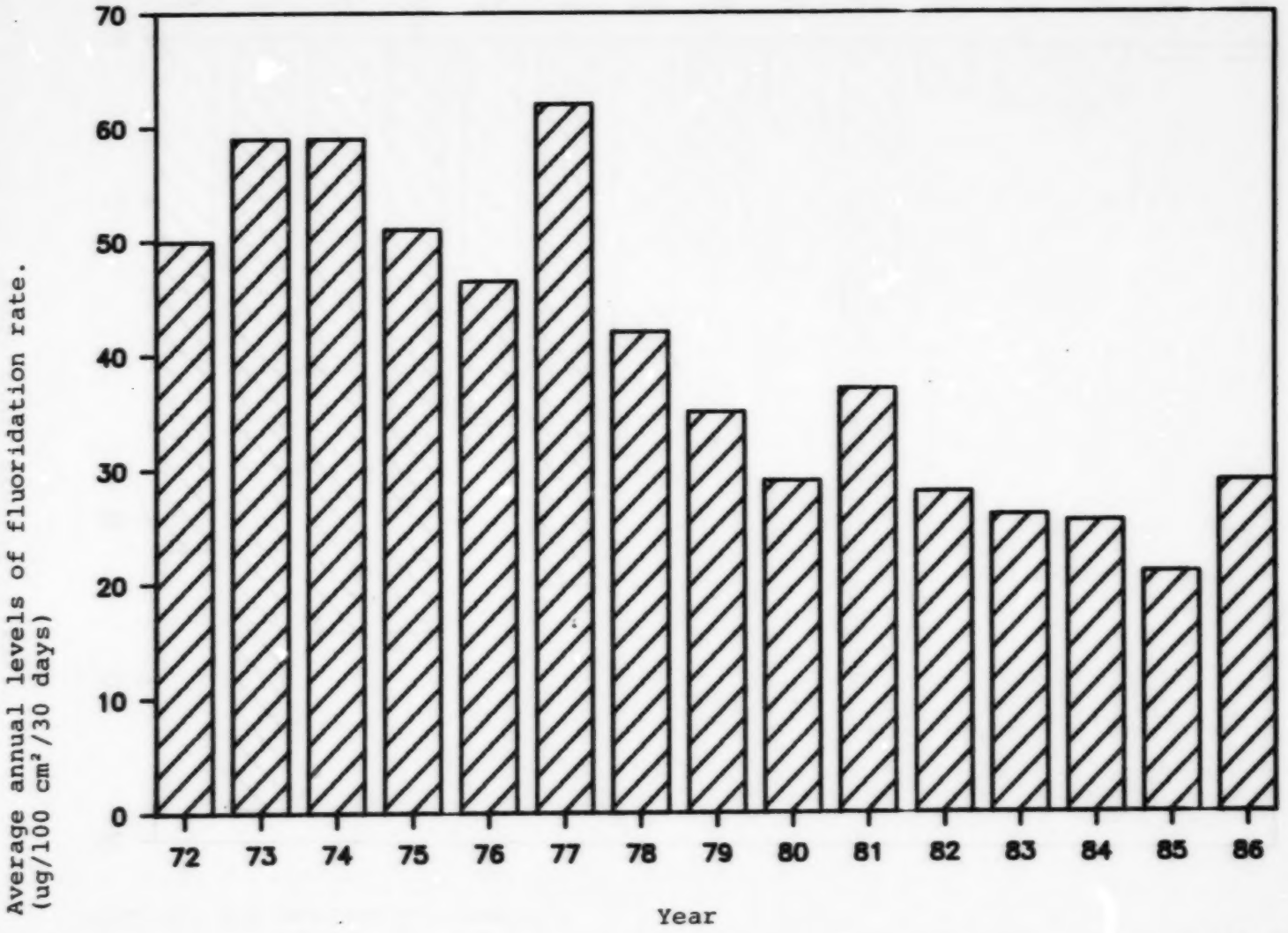
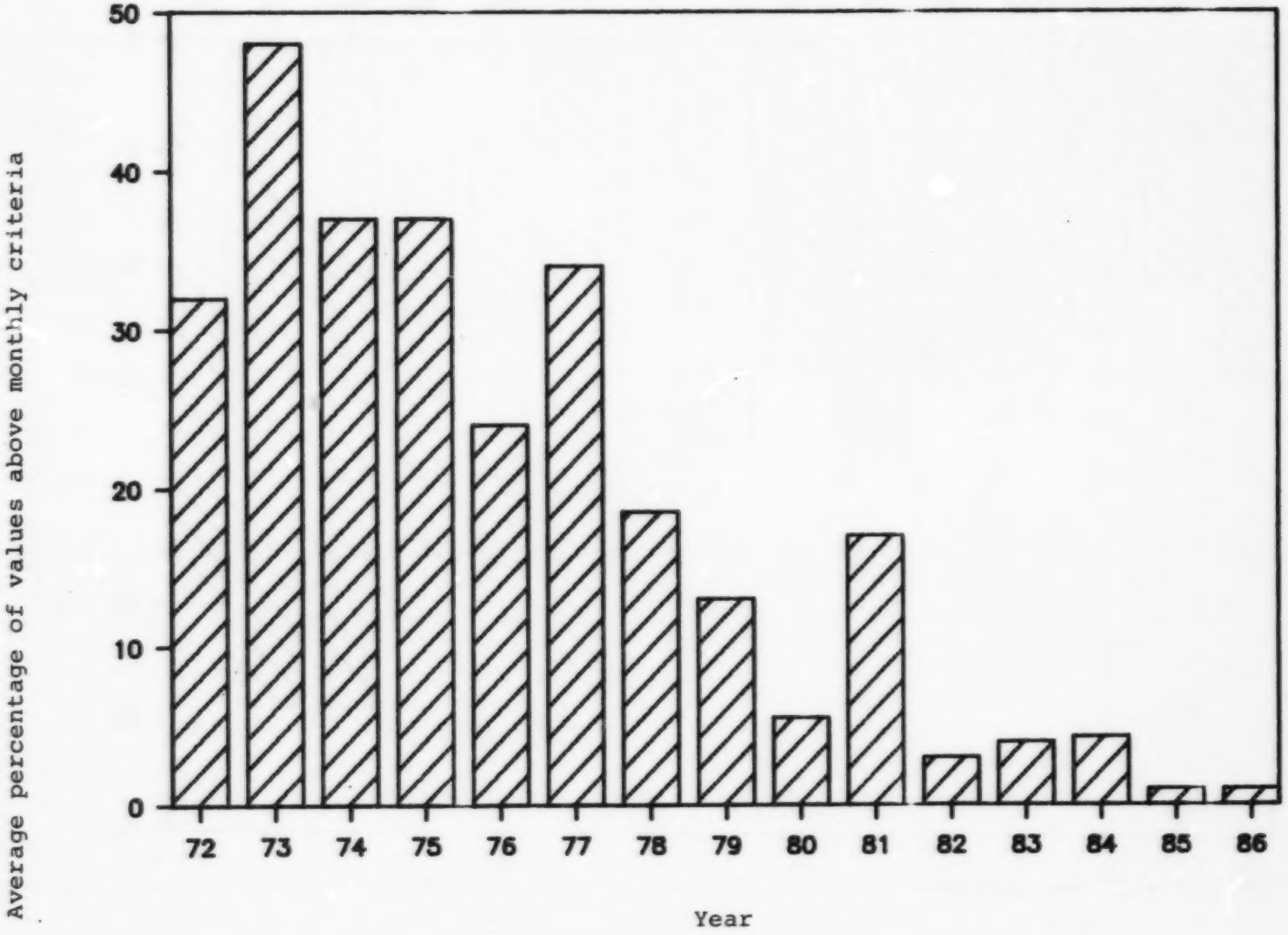


Figure 14. Trend in excursions above monthly criteria for fluoridation rate based on averaged data for six monitoring stations



APPENDIX 1

DESCRIPTION OF MONITORING NETWORK

Table A1. Locations of air monitoring stations

Station number	Location	Universal transverse mercator projection co-ordinates	Elevation above sea level (metres)	Air intake height (metres)
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12005	7730 Riverside Drive East	03395 - 46890	177	10
12006	Beach Lane/Hwy. 18 (LaSalle)	03264 - 46778	176	4
12007	Wright St./Water St.	03271 - 46823	177	4, 10 & 46
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12022	Hickory/Richmond Street	03352 - 46870	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12038	2885 Howard Ave.	03342 - 46826	195	1
12039	Dougall St./E. C. Row W	03337 - 46821	195	5
12040	225 Willow Drive (La Salle)	03261 - 46773	175	5
12047	Dorwin Plaza, Dougall Ave.	03327 - 46834	187	3
12048	Malden Rd./Laurier Ave.	03299 - 46766	178	3
12049	643 Alexandrine St.	03343 - 46832	190	1
12050	535 Charles St.	03343 - 46827	195	1
12051	604 Capital St.	03344 - 46828	195	1

Table A2. Parameters monitored in the ambient air in Windsor during 1986

Station Number	Air Pollution Index	Carbon Monoxide	Fluoridation Rate	Hydrocarbons	Nitric Oxide	Nitrogen Dioxide	Nitrogen Oxides	Ozone	Soiling Index (1-hr COH)	Sulphur Dioxide	Suspended Particulates	Total Reduced Sulphur
12002											X	
12005											X	
12006											X	
12007			X							X	X	X
12008	X	X	X	X	X	X	X	X	X	X	X	
12009											X	
12010											X	
12013										X	X	X
12015			X								X	
12016	X		X						X	X	X	
12022			X									
12027			X									
12036											X	
12037											X	
12038											X	
12039											X	
12040			X									
12047										X	X	
12048										X		
12049											X	
12050											X	
12051											X	

Table A3. Desirable ambient air quality criteria established by the Ontario Ministry of the Environment

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Fluoridation rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non-growing season)
Hydrocarbons (total)	None	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Hydrogen Sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours
Nitric oxide	None	Reacts with oxygen to produced NO_2
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against odours
	0.10 ppm averaged for 24 hours	Protection of human health and protection against odours
Oxides of nitrogen	None	

Table A3. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, property and human health
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m$_3$ averaged for 24 hours	Based on impairment of visibility and health effects
	60 ug/m$_3$ (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m$_3$ averaged for 24 hours	Based on protection of human health
Lead in suspended particulates	5.0 ug/m$_3$ averaged for 24 hours	Based on protection of human health
	2.0 ug/m$_3$ as a geometric mean over a 30 day period	Based on protection of human health
Nickel in suspended particulates	2.0 ug/m$_3$ averaged for 24 hours	Based on protection of vegetation
Vanadium in suspended particulates	2.0 ug/m$_3$ averaged for 24 hours	Based on protection of human health

APPENDIX 2

PARTICULATES

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3)

Station and Year	Cadmium			Chromium			Lead			Nickel			Vanadium		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12002															
1981	55	0.003	0.024	55	0.006	0.027	58	0.3	2.0	55	0.011	0.070	12	0.01	0.02
1982	51	0.003	0.014	51	0.007	0.090	54	0.3	1.0	51	0.007	0.027	55	0.01	0.02
1983	33	0.002	0.009	33	0.004	0.016	49	0.3	0.9	33	0.004	0.020	33	0.00	0.01
1984	34	0.002	0.012	34	0.004	0.009	57	0.1	0.6	34	0.003	0.008	34	0.01	0.02
1985	57	0.003	0.015	57	0.012	0.066	57	0.2	0.6	57	0.007	0.031	57	0.01	0.02
1986	55	0.002	0.012	55	0.010	0.045	50	0.1	0.4	55	0.007	0.150	55	0.01	0.04
12005															
1981	59	0.003	0.035	59	0.004	0.030	59	0.3	2.6	58	0.008	0.085	50	0.01	0.03
1982	54	0.005	0.022	53	0.006	0.043	54	0.2	1.1	54	0.011	0.085	54	0.00	0.02
1983	52	0.002	0.010	48	0.002	0.011	51	0.2	0.6	52	0.004	0.017	50	0.00	0.01
1984	53	0.001	0.005	53	0.004	0.034	53	0.2	0.7	49	0.004	0.036	53	0.00	0.02
1985	59	0.002	0.005	59	0.009	0.016	59	0.1	0.3	59	0.010	0.298	59	0.01	0.03
1986	52	0.001	0.009	52	0.006	0.020	52	0.1	0.5	52	0.030	0.023	52	0.01	0.04
12008															
1981	307	0.003	0.042	307	0.005	0.043	316	0.4	2.0	296	0.008	0.041	307	0.01	0.03
1982	318	0.003	0.027	317	0.005	0.024	313	0.3	1.3	318	0.007	0.071	319	0.01	0.03
1983	328	0.002	0.025	328	0.004	0.015	328	0.3	0.9	306	0.005	0.084	328	0.01	0.02
1984	344	0.003	0.031	343	0.005	0.117	345	0.3	1.1	343	0.007	0.234	343	0.01	0.14
1985	325	0.004	0.025	325	0.010	0.032	325	0.2	0.7	325	0.009	0.118	325	0.01	0.03
1986	313	0.003	0.023	313	0.009	0.042	313	0.2	1.8	313	0.004	0.150	313	0.01	0.07
12009															
1986							56	0.1	0.6						

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Cadmium			Chromium			Lead			Nickel			Vanadium		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12010															
1981	55	0.002	0.012	55	0.004	0.031	55	0.2	0.6	55	0.004	0.018	55	0.00	0.02
1982	57	0.002	0.005	56	0.002	0.009	55	0.2	0.8	57	0.006	0.018	57	0.00	0.05
1983	33	0.001	0.004	33	0.002	0.009	33	0.2	0.5	33	0.003	0.014	33	0.01	0.02
1984	32	0.001	0.004	32	0.004	0.024	32	0.2	0.7	27	0.007	0.105	32	0.00	0.03
1985	58	0.002	0.006	58	0.010	0.026	58	0.1	0.5	58	0.006	0.086	58	0.01	0.02
1986	54	0.002	0.011	54	0.008	0.049	54	0.1	0.6	54	0.005	0.037	54	0.01	0.03
12013															
1981	53	0.002	0.011	54	0.008	0.029	53	0.3	1.2	53	0.004	0.017	53	0.01	0.02
1982	56	0.003	0.014	56	0.016	0.089	54	0.3	1.3	56	0.009	0.029	56	0.01	0.04
1983	56	0.002	0.011	56	0.009	0.044	56	0.2	0.7	56	0.006	0.024	56	0.00	0.02
1984	58	0.002	0.008	58	0.008	0.056	58	0.2	0.6	53	0.007	0.031	58	0.00	0.02
1985	57	0.003	0.012	57	0.012	0.029	57	0.2	0.5	57	0.007	0.024	57	0.01	0.02
1986	60	0.002	0.013	60	0.016	0.060	60	0.2	0.5	60	0.008	0.045	60	0.01	0.03
12015															
1981	58	0.004	0.022	57	0.009	0.037	57	0.3	1.4	57	0.008	0.047	51	0.01	0.02
1982	53	0.005	0.074	53	0.008	0.059	52	0.2	0.8	53	0.010	0.102	53	0.01	0.13
1983	57	0.002	0.009	57	0.004	0.020	57	0.2	1.0	57	0.004	0.020	57	0.01	0.07
1984	47	0.003	0.027	47	0.006	0.019	47	0.1	1.0	47	0.005	0.023	47	0.00	0.02
1985	58	0.007	0.041	58	0.011	0.031	58	0.2	0.4	58	0.008	0.055	58	0.01	0.02
1986	53	0.003	0.013	53	0.012	0.047	53	0.1	0.3	53	0.006	0.019	53	0.01	0.02
12038															
1986	56	0.002	0.017	56	0.012	0.045	56	0.2	0.7	56	0.005	0.028	56	0.00	0.02

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Cadmium			Chromium			Lead			Nickel			Vanadium		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12039 1986	54	0.002	0.023	54	0.010	0.039	56	0.3	1.0	54	0.002	0.022	56	0.01	0.05
12047 1986	52	0.002	0.017	52	0.005	0.019	52	0.1	0.3	52	0.005	0.130	52	0.01	0.02
12049 1986	53	0.001	0.020	53	0.006	0.019	53	0.2	0.7	53	0.002	0.011	53	0.01	0.03
12050 1986	12	0.002	0.005	12	0.010	0.029	12	0.3	0.5	12	0.006	0.021	12	0.01	0.01
12051 1986	30	0.002	0.018	30	0.006	0.038	30	0.1	0.4	30	0.002	0.015	30	0.01	0.02

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12002															
1981	55	0.06	0.20	55	1.8	6.9	58	7.0	19.4	57	13.1	29.7			
1982	51	0.05	0.11	49	1.4	4.2	45	5.4	15.6	51	11.2	37.4			
1983	33	0.04	0.11	33	1.3	3.0	54	4.8	14.5	54	9.7	27.5			
1984	34	0.06	0.14	34	1.4	3.9	57	4.1	10.8	57	9.5	25.5			
1985	57	0.07	0.51	57	1.2	4.0	57	4.5	10.3	57	9.5	32.7			
1986	55	0.05	0.17	55	1.2	3.8	55	4.5	12.3	55	11.4	31.4			
12005															
1981	50	0.04	0.34	59	1.2	13.0	59	4.9	11.1	58	10.6	28.8			
1982	53	0.03	0.10	49	0.7	2.7	44	4.0	10.1	48	10.5	34.3			
1983	52	0.03	0.11	52	0.8	2.5	52	3.6	11.0	52	9.3	29.6			
1984	52	0.04	0.40	53	0.8	2.5	53	4.0	9.2	53	9.3	21.7			
1985	59	0.04	0.16	59	0.9	5.2	59	4.4	9.0	59	9.3	32.9			
1986	52	0.04	0.18	52	0.9	2.9	52	4.3	12.3	52	10.1	26.0			
12007															
1986				33	2.0	5.9									
12008															
1981	307	0.06	0.25	307	1.6	7.2	305	4.9	19.8	297	10.4	44.5			
1982	319	0.04	0.23	295	1.2	5.4	267	4.6	17.3	268	10.4	50.5			
1983	328	0.04	0.17	328	1.2	5.5	328	4.0	13.2	328	9.5	41.7			
1984	344	0.06	0.37	344	1.5	5.9	344	4.5	17.4	332	8.9	28.7			
1985	325	0.08	2.50	325	1.5	5.2	325	4.8	22.7	325	10.4	39.8			
1986	313	0.06	0.80	313	1.9	17.0	313	5.7	23.9	313	12.1	44.3			

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12009															
1981							55	5.3	17.5	55	11.6	24.6			
1982							43	4.5	13.7	41	10.2	26.4			
1983							53	4.1	12.7	53	10.6	32.4			
1984							55	4.1	12.0	55	9.1	20.3			
1985							55	4.2	9.9	55	9.0	30.5			
1986							56	3.8	13.1	56	8.5	30.7			
12010															
1981	55	0.04	0.42	55	0.9	4.4	58	4.5	14.3	58	11.1	36.4			
1982	56	0.02	0.09	52	0.5	1.8	56	3.1	9.7	56	8.8	19.8			
1983	33	0.02	0.04	33	0.5	1.4	33	3.2	10.3	33	8.2	19.3			
1984	32	0.02	0.05	32	0.4	1.0	32	2.9	11.2	32	9.1	24.6			
1985	58	0.04	0.17	58	0.8	5.1	58	3.8	12.2	58	9.1	33.5			
1986	54	0.04	0.20	54	1.1	4.2	54	4.4	12.9	54	10.4	33.7			
12013															
1981	53	0.06	0.20	56	1.8	6.4									
1982	56	0.15	0.92	53	2.6	8.3									
1983	56	0.15	1.14	56	3.2	16.2									
1984	58	0.15	0.83	58	3.9	22.2									
1985	57	0.19	1.14	57	3.6	14.2									
1986	60	0.17	1.05	60	3.5	15.5									
12015															
1981	52	0.08	0.22	57	2.5	5.8	55	6.0	17.3	55	14.3	32.3			
1982	52	0.05	0.15	52	2.1	27.1	51	4.6	15.1	51	11.7	28.0			
1983	57	0.06	0.14	57	1.8	6.4	43	4.5	13.8	43	10.8	27.5			
1984	47	0.09	0.27	47	2.5	8.0	47	5.7	14.3	47	13.7	40.6	49	3.6	21.5
1985	58	0.11	0.30	58	3.0	9.6	58	6.0	22.9	58	13.6	34.1	58	6.5	34.4
1986	53	0.08	0.23	53	2.2	7.4	53	4.9	12.2	53	11.6	27.2	53	3.3	18.6

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12016															
1981				10	1.7	3.3									
1982				54	1.5	6.3									
1983				73	1.5	4.0									
1984				120	1.4	6.0									
1985				116	1.5	4.7									
1986				71	2.7	12.4									
12038															
1985	39	0.11	0.41	39	7.3	35.1									
1986	56	0.06	0.29	54	7.0	46.0	56	3.6	11.4	56	7.5	25.2	56	1.0	7.1
12039															
1981				59	1.8	10.4									
1982				52	1.5	12.4									
1983				58	2.6	14.0									
1984				56	2.3	24.8									
1985				65	1.9	10.3									
1986	56	0.05	0.20	56	1.8	8.7	56	4.8	14.3	56	10.1	27.7	56	1.4	11.1
12047															
1985	52	0.05	0.14	52	1.6	11.2									
1986	52	0.04	0.38	52	1.2	5.4	52	3.9	10.1	52	7.8	25.4	52	0.7	4.8
12049															
1985	62	0.06	0.19	62	2.3	14.2									
1986	53	0.04	0.15	53	1.6	4.4	53	4.0	14.6	53	8.0	24.3	53	0.6	4.3

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12050															
1985	63	0.09	0.38	63	5.7	50.0									
1986	12	0.08	0.23	12	4.9	18.1	12	5.6	11.4	12.	8.8	13.1	12	3.6	10.2
12051															
1986	30	0.05	0.12	30	2.1	6.5	30	3.6	13.4	30	7.5	17.0	30	0.7	3.0

APPENDIX 3

TOTAL REDUCED SULPHUR, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A5. Summary of data for total reduced sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and ozone.

Parameter	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976
Station 12008											
Carbon monoxide											
Annual average (ppm)	1	1	1	1	1	1	2	2	2	2	4
Percentage of values greater than:											
1-hour criterion	0	0	0	0	0	0	0	0	0	0	0
8-hour criterion	0	0	0	0	0	0	0	0	0	0	0
Nitrogen dioxide											
Annual average (ppm)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03
Percentage of values greater than:											
1-hour criterion	0	0	0	0	0	0	0	0	0.01	0	0
24-hour criterion	0	0	0	0	0	0	0	0	0	0	0
Nitric oxide											
Annual average (ppm)	0.02	0.02	0.03	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.03
Total oxides of nitrogen											
Annual average (ppm)	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.07	0.07	0.06
Total hydrocarbons											
Annual average (ppm)	2.2	2.1	2.3	2.1	2.1	2.1	2.2	1.9[a]	2.3	2.4	2.6
Reactive hydrocarbons											
Annual average	0.3	0.4	0.4	0.3	0.4	0.4					
Ozone											
Annual average (ppm)	0.017	0.020	0.019	0.019	0.018	0.019	0.020	0.016	0.018	0.021	0.021
Percentage of values greater than 1-hour criterion	0.5	0.9	1.7	1.4	0.6	1.3	1.8	0.8	2.4	3.1	2.5

(a) based on 9 months of data

Table A5. Continued

Parameter	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976
Station 12007											
Total reduced sulphur											
Annual average (ppb)	2.0	2.0	1.3 (a)								
Percentage of values greater than:											
1-hour criterion	2.04	.079	0.70								
Station 12013											
Total reduced sulphur											
Annual average (ppb)	0.3	1.4	1.5 (a)								
Percentage of values greater than:											
1-hour criterion	0.00	0.00	0.00								

(a) 7 months of data